Claims

1. A detector for use in a mass spectrometer, said detector comprising:

a microchannel plate, wherein in use particles are received at an input surface of said microchannel plate and electrons are released from an output surface of said microchannel plate, said output surface having a first area; and

a detecting device having a detecting surface arranged to receive in use at least some of the electrons released from said microchannel plate, said detecting surface having a second area;

wherein at a first time t_1 electrons released from said microchannel plate are received on a first portion or region of said detecting surface and at a second later time t_2 electrons released from said microchannel plate are received on a second different portion or region of said detecting surface.

2. A detector as claimed in claim 1, wherein at a third time t_3 later than said second time t_2 electrons released from said microchannel plate are received on said first portion or region of said detecting surface.

3. A detector as claimed in claim 2, wherein at a fourth time t_4 later than said third time t_3 electrons released from said microchannel plate are received on said second portion or region of said detecting surface.

4. A detector as claimed in claim 1, wherein said second area is substantially greater than said first area.

5. A detector as claimed in claim 4, wherein said second area is at least 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45%, 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95% or 100% greater than said first area.

6. A detector as claimed in claim 4, wherein said second area is at least 150%, 200%, 250%, 300%, 350%, 400%, 450% or 500% greater than said first area.

7. A detector as claimed in claim 1, wherein in use x electrons per unit area are on average released from said output surface and in use y electrons per unit area are on average received on either said first portion or region and/or said second portion or region of said detecting surface.

8. A detector as claimed in claim 7, wherein x > y.

9. A detector as claimed in claim 8, wherein x is at least 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45%, 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95% or 100% greater than y.

10. A detector as claimed in claim 8, wherein x is at least 150%, 200%, 250%, 300%, 350%, 400%, 450% or 500% greater than y.

11. A detector as claimed in claim 7, wherein x is substantially equal to y.

12. A detector as claimed in claim 7, wherein x < y.

13. A detector as claimed in claim 12, wherein x is at least 5%, 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45%, 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%, or 100% less than y.

14. A detector as claimed in claim 12, wherein x is at least 150%, 200%, 250%, 300%, 350%, 400%, 450% or 500% less than y.

15. A detector as claimed in claim 1, wherein said particles comprise ions.

16. A detector as claimed in claim 1, wherein said particles comprise photons or electrons.

17. A detector as claimed in claim 1, wherein in use electrons released from said output surface of said microchannel plate are released into a region having an electric field.

18. A detector as claimed in claim 17, wherein at said first time t_1 said electric field is in a first electric field direction and wherein at said second later time t_2 said electric field is in a second different electric field direction.

19. A detector as claimed in claim 18, wherein at a third time t_3 later than said second time t_2 said electric field is in said first electric field direction.

20. A detector as claimed in claim 19, wherein at a fourth time t_4 later than said third time t_3 said electric field is in said second electric field direction.

21. A detector as claimed in claim 18, wherein said first and/or said second electric field directions are inclined at an angle to the normal of said microchannel plate.

22. A detector as claimed in claim 17, wherein in use the direction of said electric field is varied substantially continuously with time so as to substantially continuously move, guide or rotate electrons released from said output surface of said microchannel plate around, across or over said detecting surface.

23. A detector as claimed in claim 17, wherein in use the direction of said electric field is varied in a substantially stepped manner with time so as to substantially move, guide or rotate electrons released from said output surface of said microchannel plate around, across or over said detecting surface in a substantially stepped manner.

24. A detector as claimed in claim 17, wherein at said first time t_1 said electric field has a first electric field strength and wherein at said second later time t_2 said electric field has a second electric field strength.

25. A detector as claimed in claim 24, wherein said first electric field strength is substantially the same as said second electric field strength.

26. A detector as claimed in claim 24, wherein said first electric field strength is substantially different to said second electric field strength.

27. A detector as claimed in claim 26, wherein at a third time t_3 later than said second time t_2 said electric field has said first electric field strength.

28. A detector as claimed in claim 27, wherein at a fourth time t_4 later than said third time t_3 said electric field has said second electric field strength.

29. A detector as claimed in claim 26, wherein in use said electric field strength is varied substantially continuously with time so as to substantially continuously move, guide or rotate electrons released from said output surface of said microchannel plate around, across or over said detecting surface.

30. A detector as claimed in claim 26, wherein in use said electric field strength is varied in a substantially stepped manner with time so as to move,

guide or rotate electrons released from said output surface of said microchannel plate around, across or over said detecting surface.

31. A detector as claimed in claim 1, further comprising at least one reflecting electrode for reflecting electrons towards said detecting device.

32. A detector as claimed in claim 31, wherein said at least one reflecting electrode is arranged in a plane substantially parallel to said microchannel plate.

33. A detector as claimed in claim 31, wherein said at least one reflecting electrode is arranged so as to guide electrons released from said microchannel plate on to said first portion or region of said detecting surface at said first time t_1 and to guide electrons released from said microchannel plate on to said second portion or region of said detecting surface at said second later time t_2.

34. A detector as claimed in claim 1, further comprising one or more electrodes arranged between said microchannel plate and said detecting device such that an electric field is provided between said microchannel plate and said detecting device.

35. A detector as claimed in claim 34, wherein said one or more electrodes comprises one or more annular electrodes.

36. A detector as claimed in claim 34, wherein said one or more electrodes comprises one or more Einzel lens arrangements comprising three or more electrodes.

37. A detector as claimed in claim 34, wherein said one or more electrodes comprises one or more segmented rod sets.

38. A detector as claimed in claim 34, wherein said one or more electrodes comprises one or more tubular electrodes.

39. A detector as claimed in claim 34, wherein said one or more electrodes comprises one or more quadrupole, hexapole, octapole or higher order rod sets.

40. A detector as claimed in claim 34, wherein said one or more electrodes comprises a plurality of electrodes having apertures through which electrons are transmitted in use, said apertures having substantially the same area.

41. A detector as claimed in claim 34, wherein said one or more electrodes comprise a plurality of electrodes having apertures through which electrons are transmitted in use, said apertures becoming progressively smaller or larger in a direction towards said detecting device.

42. A detector as claimed in claim 1, wherein in use said output surface of said microchannel plate is maintained at a first potential and said detecting

surface of said detecting device is maintained at a second potential.

43. A detector as claimed in claim 42, wherein said second potential is more positive than said first potential.

44. A detector as claimed in claim 43, wherein the potential difference between said surface of said detecting device and said output surface of said microchannel plate is selected from the group consisting of: (i) 0-50 V; (ii) 50-100 V; (iii) 100-150 V; (iv) 150-200 V; (v) 200-250 V; (vi) 250-300 V; (vii) 300-350 V; (viii) 350-400 V; (ix) 400-450 V; (x) 450-500 V; (xi) 500-550 V; (xii) 550-600 V; (xiii) 600-650 V; (xiv) 650-700 V; (xv) 700-750 V; (xvi) 750-800 V; (xvii) 800-850 V; (xviii) 850-900 V; (xix) 900-950 V; (xx) 950-1000 V; (xxi) 1.0-1.5 kV; (xxii) 1.5-2.0 kV; (xxiii) 2.0-2.5 kV; (xxiv) > 2.5 kV; and (xxv) < 10 kV.

45. A detector as claimed in claim 1, wherein in use said output surface of said microchannel plate is maintained at a first potential, said detecting surface of said detecting device is maintained at a second potential and one or more electrodes disposed between said microchannel plate and said detecting surface are maintained at a third potential.

46. A detector as claimed in claim 45, wherein in use one or more electrodes disposed between said microchannel plate and said detecting surface are maintained at a fourth potential.

47. A detector as claimed in claim 46, wherein in use one or more electrodes disposed between said microchannel plate and said detecting surface are maintained at a fifth potential.

48. A detector as claimed in claim 47, wherein said third and/or fourth and/or fifth potential is substantially equal to said first and/or second potential.

49. A detector as claimed in claim 47, wherein said third and/or fourth and/or fifth potential is more positive than said first and/or second potential.

50. A detector as claimed in claim 47, wherein said third and/or fourth and/or fifth potential is more negative than said first and/or second potential.

51. A detector as claimed in claim 47, wherein the potential difference between said third and/or fourth and/or fifth potential and said first and/or said second potential is selected from the group consisting of: (i) 0-50 V; (ii) 50-100 V; (iii) 100-150 V; (iv) 150-200 V; (v) 200-250 V; (vi) 250-300 V; (vii) 300-350 V; (viii) 350-400 V; (ix) 400-450 V; (x) 450-500 V; (xi) 500-550 V; (xii) 550-600 V; (xiii) 600-650 V; (xiv) 650-700 V; (xv) 700-750 V; (xvi) 750-800 V; (xvii) 800-850 V; (xviii) 850-900 V; (xix) 900-950 V; (xx) 950-1000 V; (xxi) 1.0-1.5 kV; (xxii) 1.5-2.0 kV; (xxiii) 2.0-2.5 kV; (xxiv) > 2.5 kV; and (xxv) < 10 kV.

52. A detector as claimed in claim 47, wherein said third and/or fourth and/or fifth potential is intermediate said first and/or said second potential.

53. A detector as claimed in claim 1, wherein in use electrons released from said output surface of said microchannel plate are released into a region having a magnetic field.

54. A detector as claimed in claim 53, further comprising one or more magnets and/or one or more electromagnets arranged such that said magnetic field is provided between said microchannel plate and said detecting device.

55. A detector as claimed in claim 53, wherein at said first time t_1 said magnetic field is in a first magnetic field direction and wherein at said second later time t_2 said magnetic field is in a second different magnetic field direction.

56. A detector as claimed in claim 55, wherein at a third time t_3 later than said second time t_2 said magnetic field is in said first magnetic field direction.

57. A detector as claimed in claim 56, wherein at a fourth time t_4 later than said third time t_3 said magnetic field is in said second magnetic field direction.

58. A detector as claimed in claim 55, wherein said first magnetic field direction and/or said second magnetic field direction are substantially parallel to said microchannel plate.

59. A detector as claimed in claim 53, wherein in use the direction of said magnetic field is varied substantially continuously with time so as to substantially continuously move, guide or rotate electrons released from said output surface of said microchannel plate around, across or over said detecting surface.

60. A detector as claimed in claim 53, wherein in use the direction of said magnetic field is varied in a substantially stepped manner with time so as to substantially move, guide or rotate electrons released from said output surface of said microchannel plate around, across or over said detecting surface in a substantially stepped manner.

61. A detector as claimed in claim 53, wherein at said first time t_1 said magnetic field has a first magnetic field strength and wherein at said second time t_2 said magnetic field has a second magnetic field strength.

62. A detector as claimed in claim 61, wherein said first magnetic field strength is substantially the same as said second magnetic field strength.

63. A detector as claimed in claim 61, wherein said first magnetic field strength is substantially different to said second magnetic field strength.

64. A detector as claimed in claim 63, wherein at a third time t_3 later than said second time t_2 said magnetic field has said first magnetic field strength.

65. A detector as claimed in claim 64, wherein at a fourth time t_4 later than said third time t_3 said magnetic field has said second magnetic field strength.

66. A detector as claimed in claim 63, wherein in use said magnetic field strength is varied substantially continuously with time so as to substantially continuously move, guide or rotate electrons released from said output surface of said microchannel plate around, across or over said detecting surface.

67. A detector as claimed in claim 63, wherein in use said magnetic field strength is varied in a substantially stepped manner with time so as to move, guide or rotate electrons released from said output surface of said microchannel plate around, across or over said detecting surface.

68. A detector as claimed in claim 1, further comprising a grid electrode arranged between said microchannel plate and said detecting device.

69. A detector as claimed in claim 68, wherein said grid electrode is substantially hemispherical or otherwise non-planar.

70. A detector as claimed in claim 1, wherein said detecting device comprises a single detecting region.

71. A detector as claimed in claim 70, wherein said single detecting region comprises: (i) an electron multiplier; (ii) a scintillator; or (iii) a photo-multiplier tube.

72. A detector as claimed in claim 70, wherein said single detecting region comprises one or more microchannel plates.

73. A detector as claimed in claim 72, wherein one or more microchannel plates receives in use over a first number of channels at least some electrons released from a second number of channels of said microchannel plate arranged upstream of said detecting device, wherein said first number of channels is substantially greater than said second number of channels.

74. A detector as claimed in claim 72, wherein said one or more microchannel plates receives in use over a first number of channels at least some electrons released from a second number of channels of said microchannel plate arranged upstream of said detecting device, wherein said first number of channels is substantially equal to said second number of channels.

75. A detector as claimed in claim 72, wherein said one or more microchannel plates receives in use over a first number of channels at least some electrons released from a second number of channels of said microchannel plate arranged upstream of said detecting device, wherein said first number of channels is substantially less than said second number of channels.

76. A detector as claimed in claim 1, wherein said detecting device comprises a first detecting region and at least a second separate detecting region.

77. A detector as claimed in claim 76, wherein said second detecting region is spaced apart from said first detecting region.

78. A detector as claimed in claim 76, wherein said first and second detecting regions have substantially equal detecting areas.

79. A detector as claimed in claim 76, wherein said first and second detecting regions have substantially different detecting areas.

80. A detector as claimed in claim 79, wherein the area of said first detecting region is greater than the area of said second detecting region by a percentage p, wherein p is selected from the group consisting of: (i) < 10%; (ii) 10-20%; (iii) 20-30%; (iv) 30-40%; (v) 40-50%; (vi) 50-60%; (vii) 60-70%; (viii) 70-80%; (xi) 80-90%; and (x) > 90%.

81. A detector as claimed in claim 79, wherein in use the number of electrons received by said first detecting area is greater than the number of electrons received by said second detecting area by a percentage q, wherein q is selected from the group consisting of: (i) < 10%; (ii) 10-20%; (iii) 20-30%; (iv) 30-40%; (v) 40-50%; (vi) 50-60%; (vii) 60-70%; (viii) 70-80%; (xi) 80-90%; and (x) > 90%.

82. A detector as claimed in claim 76, wherein said first detecting region comprises: (i) one or more microchannel plates; (ii) an electron multiplier; (iii) a scintillator; or (iv) a photo-multiplier tube.

83. A detector as claimed in claim 76, wherein said second detecting region comprises: (i) one or more microchannel plates; (ii) an electron multiplier; (iii) a scintillator; or (iv) a photo-multiplier tube.

84. A detector as claimed in any claim 1, wherein said detecting device comprises at least one chevron pair of microchannel plates.

85. A detector as claimed in claim 1, further comprising at least one collector plate arranged to receive in use at least some electrons generated or released by said detecting device.

86. A detector as claimed in claim 85, wherein said at least one collector plate is shaped to at least partially compensate for a temporal spread in the flight time of electrons incident on said detecting device.

87. A detector as claimed in claim 1, wherein said detecting device is shaped to at least partially compensate for a temporal spread in the flight time of electrons incident on said detecting device.

88. A detector as claimed in claim 1, further comprising one or more electrodes arranged so as to at least partially compensate for a temporal spread in the flight time of electrons incident on said detecting device.

89. A detector as claimed in claim 34, wherein in use a time varying potential is applied to at least one of said one or more electrodes.

90. A detector as claimed in claim 89, wherein an amplitude of said time varying potential varies substantially sinusoidally with time.

91. A detector as claimed in claim 89, wherein an amplitude of said time varying potential varies with time at a frequency selected from the group consisting of: (i) 10-50 Hz; (ii) 50-100 Hz; (iii) 100-150 Hz; (iv) 150-200 Hz; (v) 200-250 Hz; (vi) 250-300 Hz; (vii) 300-350 Hz; (viii) 350-400 Hz; (ix) 400-450 Hz; (x) 450-500 Hz; (xi) 500-550 Hz; (xii) 550-600 Hz; (xiii) 600-650 Hz; (xiv) 650-700 Hz; (xv) 700-750 Hz; (xvi) 750-800 Hz; (xvii) 800-850 Hz; (xviii) 850-900 Hz; (xix) 900-950 Hz; (xx) 950-1000 Hz; (xxi) 1.0-1.5 kHz; (xxii) 1.5-2.0 kHz; (xxiii) 2.0-2.5 kHz; (xxiv) 2.5-3.5 kHz; (xxv) 3.5-4.5 kHz; (xxvi) 4.5-5.5 kHz; (xxvii) 5.5-7.5 kHz; (xxviii)

7.5-9.5 kHz; (xxix) 9.5-12.5 kHz; (xxx) 12.5-15 kHz; (xxxi) 15.0-20.0 kHz and (xxxii) > 20 kHz.

92. A detector as claimed in claim 89, wherein an amplitude of said time varying potential varies with time at a frequency of between 50 Hz and 10 kHz.

93. A detector as claimed in claim 1, wherein said microchannel plate comprises a plurality of channels and wherein at least some of the electrons released from separate channels of said microchannel plate are received on substantially separate non-overlapping regions on said detecting surface.

94. A detector as claimed in claim 1, wherein said detecting surface extends circumferentially and continuously around said output surface of said microchannel plate.

95. A detector as claimed in claim 1, wherein said detecting device is in substantially the same plane as said microchannel plate.

96. A mass spectrometer comprising a detector as claimed in claim 1.

97. A mass spectrometer as claimed in claim 96, wherein said detector forms part of a Time of Flight mass analyser.

98. A mass spectrometer as claimed in claim 96, further comprising an Analogue to Digital Converter ("ADC") connected to said detector.

99. A mass spectrometer as claimed in claim 96, further comprising a Time to Digital Converter ("TDC") connected to said detector.

100. A mass spectrometer as claimed in claim 96, further comprising an ion source selected from the group consisting of: (i) an Electrospray Ionisation ("ESI") ion source; (ii) an Atmospheric Pressure Ionisation ("API") ion source; (iii) an Atmospheric Pressure Chemical Ionisation ("APCI") ion source; (iv) an Atmospheric Pressure Photo Ionisation ("APPI") ion source; (v) a Laser Desorption Ionisation ("LDI") ion source; (vi) an Inductively Coupled Plasma ("ICP") ion source; (vii) a Fast Atom Bombardment ("FAB") ion source; (viii) a Liquid Secondary Ion Mass Spectrometry ("LSIMS") ion source; (ix) a Field Ionisation ("FI") ion source; (x) a Field Desorption ("FD") ion source; (xi) an Electron Impact ("EI") ion source; (xii) a Chemical Ionisation ("CI") ion source; and (xiii) a Matrix Assisted Laser Desorption Ionisation ("MALDI") ion source.

101. A mass spectrometer as claimed in claim 100, wherein said ion source is continuous or pulsed.

102. A method of detecting particles comprising;

receiving particles at an input surface of a microchannel plate;

releasing electrons from an output surface of said microchannel plate, said output surface having a first area; and

receiving at least some of said electrons on a detecting surface of a detector having a second area;

wherein at a first time t_1 electrons released from said microchannel plate are received on a first portion or region of said detecting surface and at a second later time t_2 electrons released from said microchannel plate are received on a second different portion or region of said detecting surface.

103. A method of mass spectrometry comprising a method of detecting particles as claimed in claim 102.